Southwest
Great Plains

Research Note RM-489

February 1989

USDA Forest Service

Rocky Mountain Forest and Range Experiment Station

Improved Procedures for Installing and Operating Precipitation Gages and Alter Shields on Windswept Lands

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This note describes materials to speed the installation of a recording precipitation gage and a modified Alter windshield, as well as techniques to improve the operating performance of gages in locations where blowing snow and cold temperatures are common. Materials cost about $110.

Keywords: Precipitation gage, modified Alter shield, installation of precipitation gages

Obtaining reliable precipitation data in windswept regions remains a vexing problem. It is essential that wind velocity near the gage orifice be stilled sufficiently to allow particles to fall into the gage reservoir. Alter (1937) showed that baffles placed around the gage improve gage performance when precipitation falls as snow. The configuration of shield elements was improved by Warnick (1953), who recommended that the shield extend 13 mm above the gage orifice. The wind baffle adopted by the National Oceanic and Atmospheric Administration for use in the United States, commonly known as the modified Alter windshield, is 117 cm in diameter and installed concentric with the gage while extending 13 mm above the orifice (U.S. Weather Bureau 1955).

The receiver funnel should be placed about 1 m above the ground surface where precipitation falls as rain (USDA ARS 1962), but it is commonly placed at a 3.0-m height where snow accumulates. It is important that the orifice be level as a systematic error is introduced into data when the orifice is not level (Rinehart 1983). It is also important that the gage and the Alter shield be independently supported so that vibrations from the windshield are not transmitted to the gage. Such vibrations cause the pen of recording gages to "paint" a wide trace that can obscure the beginning and ending of precipitation events when storms are accompanied by wind.

Installing precipitation gages so that the orifice is level and the modified Alter windshield is properly oriented and independently supported is a tedious task. Our procedures ease difficulties in installing precipitation gages and improve the operating performance of gages, particularly those located in windswept regions; these procedures have evolved over a 20-year period of collecting reliable precipitation data from locations on the inhospitable plains and mountain regions of Wyoming.

The materials described are those required to mount a Belfort[2] weighing and recording precipitation gage at 3.0 m. Adaptations can be easily made for nonrecording gages and for mounting heights other than 3.0 m. A cutting torch and welding equipment are required to fabricate the leveling plate and some of the components used to support the modified Alter windshield.

Materials and Construction

Leveling Plate

The leveling plate is mounted on the post supporting the precipitation gage and, in combination with threaded

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[2]*The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others that may be suitable.*

rod and nuts, is used to level the gage. Construction plans for the leveling plate and associated components are shown in figure 1. The leveling plate is 36 cm in diameter and is cut from plate steel 6 mm thick. Two holes are drilled 2.5 cm from the center of the leveling plate if the gage is to be mounted on a wooden post. Three additional holes are drilled through the plate to coincide with the three mounting holes in the base plate of the precipitation gage. The base plate is centered on the steel plate and used as a template to mark the location of mounting holes. Three pieces of threaded rod cut into 12 cm lengths along with 12 nuts are used to level and fasten the base plate of the precipitation gage to the leveling plate.

Alter Windshield Support

Figure 2 shows the relationship between the gage orifice and the modified Alter windshield, as well as the centering rings, and the galvanized pipe legs that support the windshield. Construction drawings for components required to install the windshield are shown in figures 3-5. The shield is supported by three pieces of galvanized pipe 2.5 cm in diameter and 45 cm long that telescope within galvanized pipe 3.8 cm in diameter and 1.5 m long. The telescoping action allows Alter shield height to be precisely controlled. The larger diameter pipe attaches to wooden posts seated in the ground. The insides of the three posts are located 1.37 m from the center of the post supporting the gage on lines that radiate at angles of 120° from the support post.

The rod supporting individual baffles of the modified Alter shield is attached to three centering rings that rest upon a piece of angle iron welded to one end of the 2.5-cm-diameter pipe. Adjustment of the Alter shield horizontally so it is concentric with the gage is accomplished by sliding the centering rings across the top of the angle iron. A circular piece 8 cm in diameter cut from the center of the ring allows the horizontal adjustment. The centering ring is locked into place once the Alter shield is positioned by bolting a piece of angle iron placed on top of the centering ring to the angle iron that lies below the centering ring.

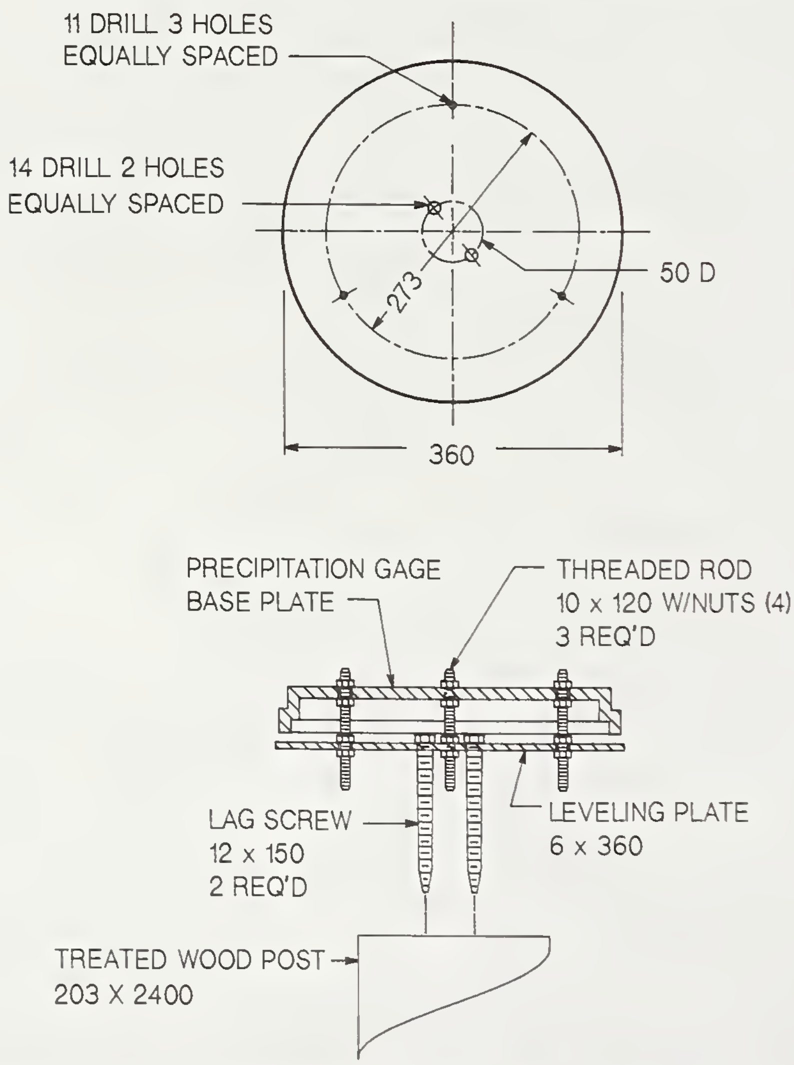

Figure 1.—Fabrication plans for the leveling plate and the attachments to the gage support post; dimensions are in millimeters. The leveling plate in conjunction with the base plate of the precipitation gage allows the orifice of the gage to be quickly leveled.

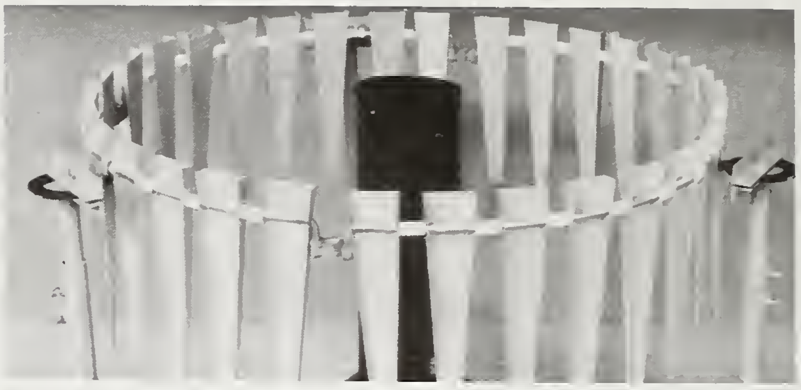

Figure 2.—Orientation of the gage orifice and the modified Alter windshield. The pieces of angle iron, centering rings, and galvanized pipes that support the windshield are visible in the photograph.

Gage Modifications

Vertical extension of gage orifice.—During large snowfall events, snow can build up on the sloped sides of the collector assembly below the orifice and then bridge across the orifice (capping). A plug of snow may drop into the bucket at a later date that may or may not be representative of true snowfall. All information about storm intensity is lost when capping occurs.

Snow capping can be prevented by raising the orifice an additional 60 cm (fig. 6). Stove pipe 20 cm in diameter works well for gages with an opening this size. An extension can also be fabricated from sheet metal by a tinsmith. The extension should slip inside the collector assembly about 5 cm. The extension and receiver funnel are fastened together at the overlap with four sheet metal screws. The head of each screw is on the exterior side of the collector assembly and that portion of the screw extending through the extension is ground off. Silicone calk should be applied to any nonwatertight joint to insure that only precipitation falling through the orifice enters the reservoir. The collector assembly and the vertical extension should be painted black to promote

melting of snow so that the extension and collector funnel are not blocked by a buildup of ice or snow.

Preventing snow from blowing inside gage casing.— The joint between the collector assembly and the outer casing of a recording precipitation gage is sufficiently

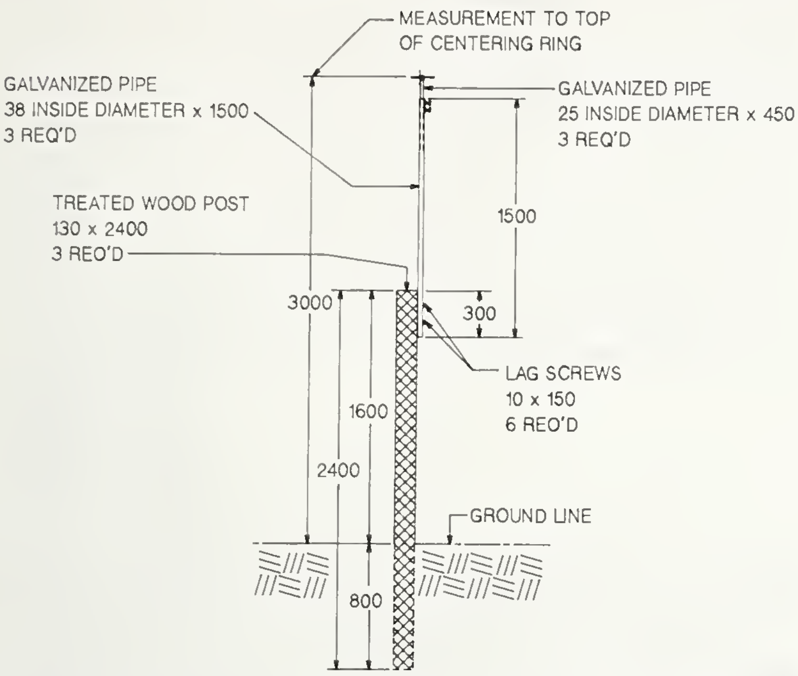

Figure 3.—Fabrication plans showing wooden post, galvanized pipe, and centering ring used to support the modified Alter windshield; dimensions are in millimeters.

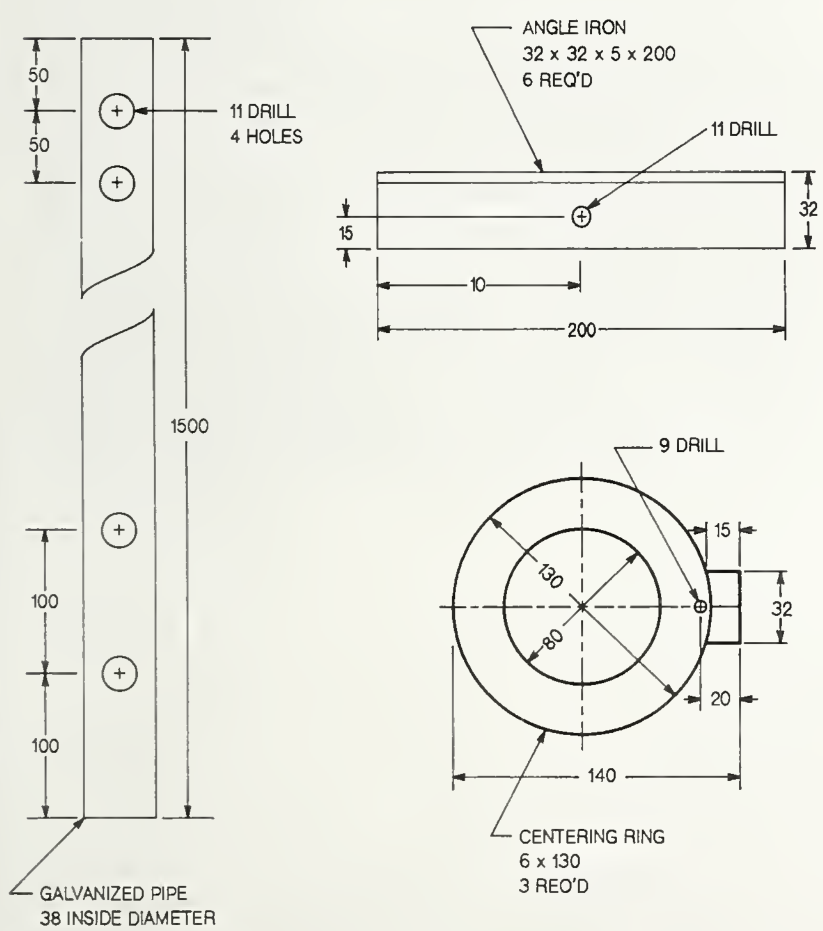

Figure 4.—Drawing of angle iron, centering ring, and galvanized pipe 38 mm in diameter and 1.5 m long; dimensions are in millimeters.

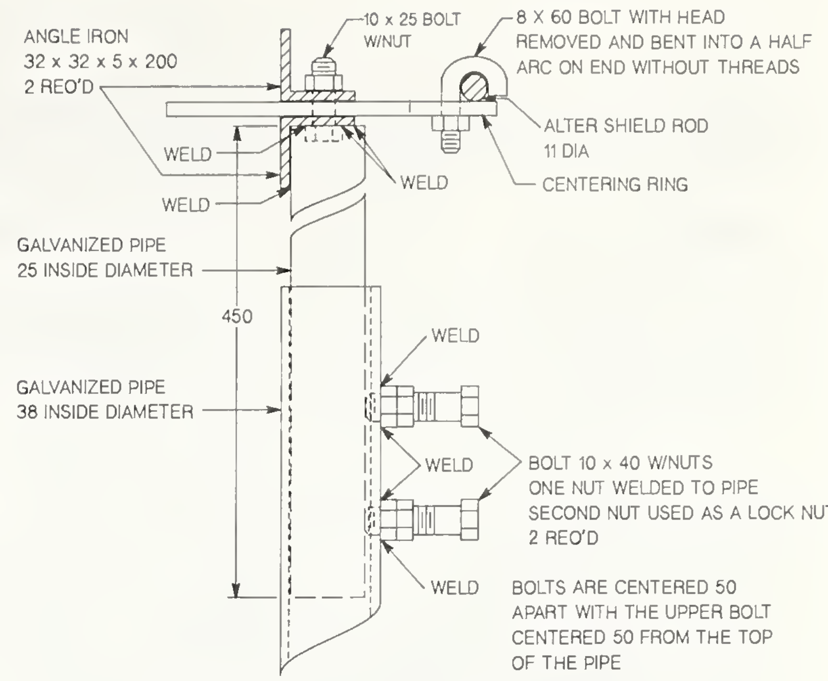

Figure 5.—Drawing showing attachment of modified Alter windshield rod to centering ring, attachment of centering ring to telescoping pipe 25 mm in diameter, and the position of nuts and bolts used to lock telescoping pipe in position; dimensions are in millimeters.

Figure 6.—Covering the joint between the collector assembly and outer casing of a recording precipitation gage with elastic material prevents snow from infiltrating through the joint when gages are located on windswept sites (left). Snow capping can be prevented by raising the orifice 60 cm (right). The orifice extension and collector assembly have been painted black to promote melting of snow.

loose that the wind can drive snow particles through the gap. On windswept sites, snow can infiltrate through the joint in storms accompanied by high winds, or at a later time when winds are sufficiently strong to transport substantial quantities of snow at gage height. Some snow will fall into the reservoir bucket, leading to an unknown error. Also, snow not deposited in the reservoir will melt when the temperature is above freezing, and water can then drip onto the clock or chart drum and stop drum rotation once it refreezes.

Snow infiltration through the joint between the collector assembly and the outer casing can be prevented by covering the joint with a piece of rubber, about 8 cm in

width, that fits snugly around the joint (fig. 6). The rubber can be cut from an inner tube 30 cm in diameter, or butyl rubber or other elastic material can be used to fabricate a gasket.

Improving quality of chart trace.—The quality of the chart trace is improved by replacing the ink-reservoir pen with a fiber-tip pen.[3] There is less record loss with a fiber-tip pen than with an ink-reservoir pen, and charts are also generally cleaner because there is no ink smudging. Fiber-tip pens have sufficient ink to normally last a year, but do need replacement more often when gages are located in windswept regions where wind-induced vibrations cause frequent pen movement.

Because fiber-tip pens are heavier than ink pens, additional weight must be added to the pen counterweight to make the pen track correctly. Morris and Hanson (1983) fully describe counterweight adjustments. The gage should be recalibrated after modifications are made for the fiber-tip pen.

Field Installation

Precipitation Gage

The best location for a precipitation gage is within a small opening in a stand of trees. This type of siting reduces wind-caused undermeasurement of precipitation falling as snow, which is a particularly serious problem in windswept locations. Sturges (1986) found that snowfall measured by a Wyoming-shielded gage (Richard and Wei 1980) decreased about 7% for each 1-meter per second increase in wind speed, compared to precipitation measured at a forest-protected gage site. The quality of the chart trace in a forest-protected site is greatly superior to that of a fully exposed site even if the exposed gage is protected by a windshield, and incidence of clock stoppage is also less within a forest opening because of the reduction in wind-induced vibrations that adversely affect clock performance (fig. 7).

Brown and Peck (1962) define a well-protected gage site as one sheltered in all directions by objects subtending an angle of 20° to 30° from the gage orifice. This opening size is between 3.5 and 5.6 times the height of surrounding trees and agrees with the opening size recommended by the U.S. Weather Bureau (1963). However, we agree with Wilson (1954) that a forest opening with a diameter about equal to the height of surrounding trees (1.0 H) is best, especially for locations where winter precipitation events often are accompanied by strong winds.

The gage can be installed on a wooden or metal post or even on a cutoff tree trunk. Wooden posts should be treated with wood preservative and have a top diameter of at least 20.3 cm. The lower 80 cm of the post is buried in the ground. To minimize snow infiltration around the service door, the precipitation gage should be placed so that the service door faces away from prevailing winds.

The aboveground height of the post used to support the precipitation gage is such that the orifice is at the

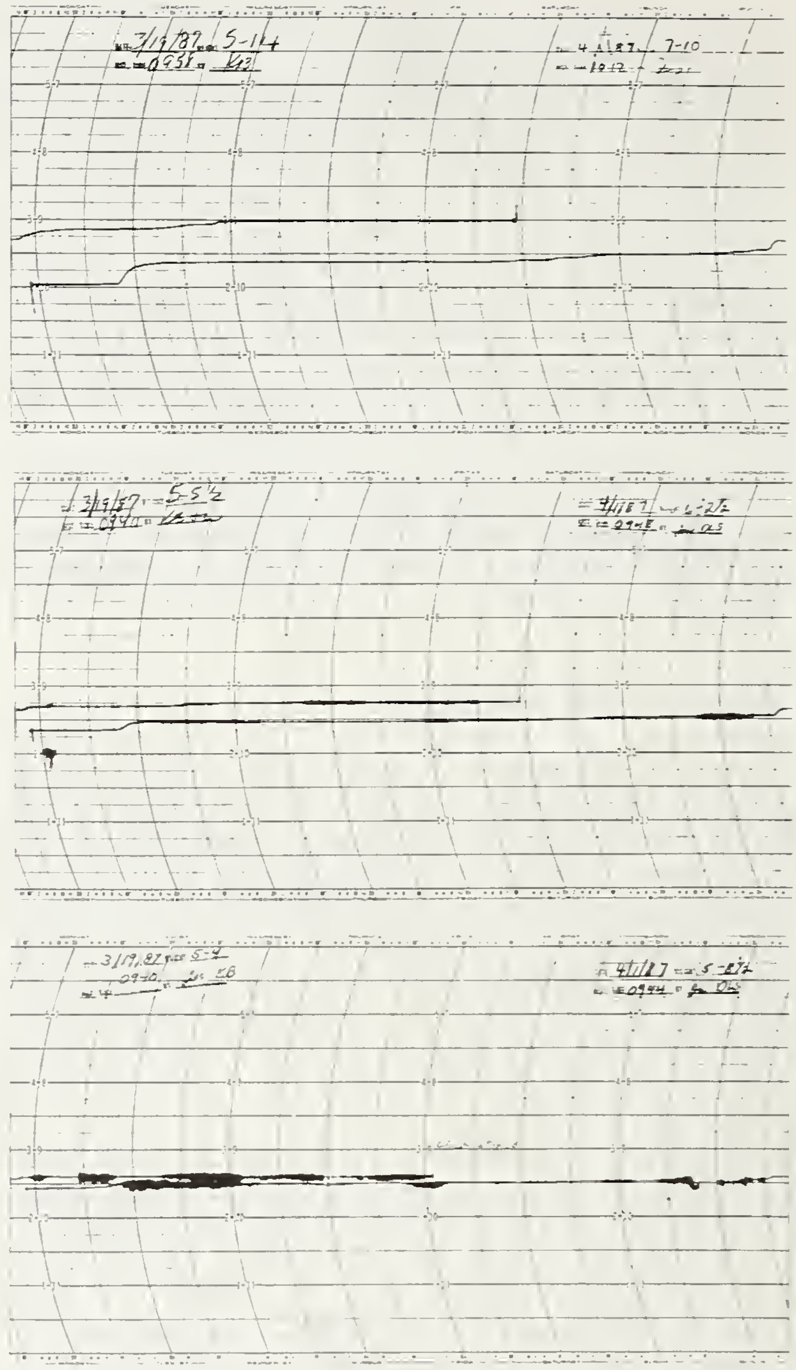

Figure 7.—Winter precipitation charts from a forest-protected gage site (top), and from gages located on adjacent windswept rangeland protected by a Wyoming windshield (center), and without wind protection (bottom). Precipitation is undermeasured in exposed locations even when the gage is protected by a windshield (center), but undermeasurement is more severe for unshielded gages (bottom). Buffeting by wind also reduces the quality of the pen trace of unshielded gages and causes frequent clock stoppages.

desired height (usually 3.0 m) when the gage is mounted on the post. Two lag bolts are used to fasten the leveling plate to a wooden post, or the plate can be welded to a metal post. The base plate need not be mounted level. The receiver funnel and outer housing are removed from the gage base plate to facilitate attaching the base plate to the steel leveling plate as shown by figure 1. The nuts on the upper and lower side of the base plate are tightened against the plate so that a few millimeters of threaded rod protrude above the upper nut. The gage is supported by the three pieces of threaded rod and the nuts positioned on top of the base plate (fig. 1). The three

[3]*Available from Graphics Control Corporation.*

legs on the base plate of the precipitation gage need not rest upon the leveling plate.

The housing and collector assembly are reattached to the base plate as the last step before leveling the gage. The nuts on the upper and lower surface of the leveling plate are turned to raise or lower the gage until the orifice is level, as indicated by a carpenter's level placed across the orifice. The nuts on the lower side of the base plate are tightened against the plate to lock the gage in place once the orifice is correctly positioned. Thereafter, the orifice should be checked once or twice a year and releveled if necessary. It is important to perform the level adjustment across the orifice, rather than across the base plate, as the orifice of the gage is not necessarily level when the base plate is level. The calibration of a recording precipitation gage should be verified using standard procedures (USDA ARS 1962) when field installation of the gage is finished.

Modified Alter Windshield

The modified Alter windshield is installed after the precipitation gage has been correctly positioned. The three wooden posts supporting the windshield should be placed to provide an access corridor to the service door of the gage. The lower end of the 3.8-cm-diameter pipe that supports the Alter shield extends 30 cm below the top of the wooden post. The pipe is placed on the side of the post facing the precipitation gage and is fastened to the wooden post with lag screws (fig. 3). The lower end of this pipe should be open so that water can drain from the pipe.

The upper steel pipe that telescopes provides about 30 cm of total height adjustment, allowing the top of individual baffles in the windshield to be positioned at the correct distance above the gage orifice. The centering rings permit the windshield to be moved up to 7 cm laterally when orienting the shield. A carpenter's level placed on a straightedge spanning the windshield is used to level the shield. The bottom of the straightedge provides a reference point for measuring the 13-mm distance between the gage orifice and the top of the windshield. A plumb line hanging from the straightedge at the center of the windshield is used to place the modified Alter windshield concentric with the gage orifice.

Literature Cited

Alter, J. C. 1937. Shielded storage precipitation gages. Monthly Weather Review. 65: 262–265.

Brown, Merle J.; Peck, Eugene L. 1962. Reliability of precipitation measurements as related to exposure. Journal of Applied Meteorology. 1: 203–207.

Morris, Ronald P.; Hanson, Clayton L. 1983. Weighing and recording precipitation gage modification. Transactions of American Society of Agricultural Engineers. 26(1): 167–168.

Rechard, Paul A.; Wei, Tsong C. 1980. Performance assessments of precipitation gages for snow measurement. Water Resources Series No. 76, Water Resources Research Institute, Univ. of Wyoming, Laramie. 195 p.

Rinehart, Ronald E. 1983. Out-of-level instruments: Errors in hydrometer spectra and precipitation measurements. Journal of Climate and Applied Meteorology. 22: 1404–1410.

Sturges, David L. 1986. Precipitation measured by dual gages, Wyoming-shielded gages, and in a forest opening. *In*: Kane, Douglas L., ed. Proceedings, Cold Regions Hydrology Symposium; Fairbanks, AK. TPS–86–1. Bethesda, MD: American Water Resources Association: 387–396.

Warnick, C. C. 1953. Experiments with windshields for precipitation gages. American Geophysical Union Transactions. 34(3): 379–385.

Wilson, Walter T. 1954. Analysis of winter precipitation observations in cooperative snow investigations. Monthly Weather Review. 82: 183–199.

U.S. Department of Agriculture, Agricultural Research Service. 1962. Field manual for research in agricultural hydrology. Agric. Handb. 224. Washington, DC: U.S. Department of Agriculture. 215 p.

U.S. Weather Bureau. 1955. Instructions for climatological observers. U.S. Weather Bureau Circular B, 10th ed.(rev.). Washington, DC: U.S. Department of Commerce. 70 p.

U.S. Weather Bureau. 1963. Observer manual for punched tape rain gages. U.S. Weather Bureau. Washington, DC: U.S. Department of Commerce.

Appendix.—Cost and Material List.

Following is a list of materials for supporting the precipitation gage, for constructing the leveling plate, and for constructing support pieces for the modified Alter windshield, and the cost of each item. Materials are used to install a recording precipitation gage at a 3.0-m height.

Quantity	Item	Cost
Gage support post		
1	treated wood post, 2.4 m long with a minimum top diameter of 20.3 cm	$12.00
Leveling plate		
1	steel plate, 36 cm in diameter x 6 mm thick	19.50
1	threaded rod, 10 mm x 46 cm	1.27
12	nuts, 10 mm	.93
2	lag screw, 12 mm x 15 cm	1.64
Alter shield support		
3	treated wood post, 2.4 m long with a minimum top diameter of 13 cm	26.85
3	galvanized pipe, 3.8 cm x 1.5 m	19.05
3	galvanized pipe, 2.5 cm x 45 cm	8.33
6	lag screw, 10 mm x 15 cm	2.40
3	bolt, 8 mm x 6 cm	.45
3	nut, 8 mm	.15
6	bolt, 10 mm x 4 cm	.90
3	bolt, 10 mm x 2.5 cm	.45
15	nut, 10 mm	1.17
3	centering ring, 13 cm in diameter x 6 mm with a 3.2 cm x 1.5 cm x 6 mm ear	10.45
6	angle iron, 3.2 cm x 3.2 cm x 5 mm, 20 cm long	6.50
	TOTAL COST	$112.04